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Reconsider.
Hawkins
11/5/02

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Daping CHU

Group Art Unit: 2834

Application No.: 09/866,740

Examiner: P. Medley

Filed: May 30, 2001

Docket No.: 109678

For: PIEZOELECTRIC DEVICES

REQUEST FOR RECONSIDERATION

Director of the U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir:

In reply to the August 2, 2002 Office Action, reconsideration of the above-identified application is respectfully requested.

Claims 1-10 are pending. Reconsideration based on the following remarks is respectfully requested.

I. The Declaration Satisfies All Formal Requirements

The Office Action asserts that the Declaration is defective because it does not identify the citizenship of the inventor. A substitute Declaration/Power of Attorney will be forwarded to the U.S. Patent and Trademark Office correctly listing the citizenship of the inventor as British.

II. The Claims Define Allowable Subject Matter

The Office Action rejects claims 1-10 under 35 U.S.C. §103 as unpatentable over U.S. Patent No. 6,320,300 to Kaminski et al. (hereinafter "Kaminski"). The rejection is respectfully traversed.

Kaminski discloses a piezoelectric array device for use as a variable resonator. In order to function as a resonator, Kaminski must use piezoelectric crystals. Kaminski discloses in

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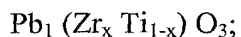
detail at column 2, line 33 to column 3, line 30, the resonant properties of piezoelectric crystals. Depending upon the crystal cut and mode, either the thickness or the length of the crystal controls the resonant frequency and also the typical range of operation. Kaminski refers consistently to the use of piezoelectric crystals because it is dependent on the crystal resonant mode. If ceramic piezoelectric materials (amorphous or crystalline) were used in the described device, the lattice elongation and crystal orientation would be extremely difficult to control to the extent that the device would not function reliably as a resonator--the resonant frequency could not be predicted from a particular expected crystal thickness or length.

The Office Action asserts that Kaminski discloses piezoelectric layers. However, Kaminski discloses, consistently throughout, the use of piezoelectric crystals. Piezoelectric crystals are quite distinct from piezoelectric layers.

The Office Action also acknowledges that Kaminski does not disclose the use of ferroelectric material in combination with a piezoelectric material. However, the Office Action considers that it would be obvious to use PZT, which can exhibit ferroelectric properties, as one of the piezoelectric crystals.

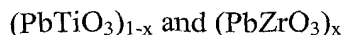
This assertion is respectfully traversed. One of ordinary skill in the art would know that PZT is a solid solution and of ceramic (polycrystalline) form. One of ordinary skill in the art would also know that it is practically impossible to produce PZT crystals, i.e., piezoelectric crystals (as required by Kaminski) of PZT.

PZT is a solid solution of lead zirconate and lead titanate and can be defined by the expression:



where x defines the ratio of the two component compounds.

In the solid solution form, the constituent elements (Zr and Ti) present would be random and therefore combine to provide a mixture of:



Thus, the lattice boundaries in the mixture are of random size, and hence cannot be defined. The mixture is therefore of polycrystalline form, and a mass, such as a layer, of this PZT solid solution cannot be predictably divided to provide structures of a predefined size which would resonate at a required frequency. Even the minute polycrystalline grains of PZT material are not of single crystal form, and instead include many twinning boundaries which render it impossible to fabricate a useful and reliable resonator. As such, one of ordinary skill in the art would know that PZT cannot be used to provide the piezoelectric crystal elements for the device disclosed by Kaminski.

Furthermore, one of ordinary skill in the art would also know that a ferroelectric material would not be selected for use in the device of Kaminski. With a piezoelectric material, electrical polarization is always in the same polarity direction as an applied electric field, and when the electric field is removed, the electrical polarization is not retained in the material, i.e., there is no remnant polarization. Ferroelectric materials exhibit polarization hysteresis and electrical polarization that is not always in the same polarity direction as an applied electric field. For example, the application of a positive electrical field across a ferroelectric material layer can cause the material to change from a remnant negative polarization state to a remnant positive polarization state, and vice versa.

This remnant polarization of ferroelectric materials would give rise to problems if used as the piezoelectric crystals of Kaminski because the polarization hysteresis, which gives rise to remnant polarization, is a variable property which would give rise to a variation in the resonant frequency exhibited by the material. Thus, the resonant frequency of the resonator of Kaminski could not be controlled by predicting the crystal cut and mode, as described for the piezoelectric crystals disclosed in Kaminski. Hence, to select PZT as a layer for the device described by Kaminski would further compound the problems caused by selection of a non-crystal material for the resonant elements. Thus, PZT would not be selected by one of ordinary skill in the art for use as a piezoelectric crystal because the random polycrystalline lattice size generated in the solid form solution of this ceramic material, and additionally the

ferroelectric properties, would not provide control of the resonant frequency dependent upon the crystal cut and mode, as is required by the device.

In strict contrast to Kaminski, the present invention necessarily requires at least one of the clamped layers to be a ferroelectric material because the remnant polarization exhibited by the ferroelectric material is used to particular effect. When an electric field is applied in parallel or anti-parallel (i.e., in the same or opposite polarity direction) to the remnant polarization, the strains induced along the polarization axis of the material are either in-phase or out-of-phase to the applied external field. This phase relationship is dependent upon the polarization direction of the remnant polarization in the ferroelectric material. Thus, if an input signal is applied, for example, to a piezoelectric material which is clamped to a ferroelectric material, the piezoelectric material will expand and contract (deform) in phase with the phase of the input signal. This is because, as explained above, in a piezoelectric material the polarization, and hence strain, induced in the material always has the same polarity or sign as the applied electric field.

The strain induced in the piezoelectric material is then passed to the layer of ferroelectric material, which has remnant polarization. However, the strain, and thus electric polarization, induced in the ferroelectric layer may be either in-phase or out-of-phase with the remnant polarization of the ferroelectric layer. The output signal will therefore depend upon this in-phase or out-of-phase relationship. Thus, as disclosed in the present application, by selection of the properties and geometry of the materials of the layers, the clamped structure of the invention can be used to provide an amplifier, transformer, comparator or inverter. In contrast, Kaminski can only be used to provide a variable resonator and it is this resonator which can be used in certain circuit types, such as a filter circuit.

In summary, Kaminski discloses a variable resonator which is reliant upon the use of piezoelectric crystals and which is reliant upon avoiding the use of ferroelectric materials which exhibit a remnant polarization effect. In strict contrast, the claimed invention relies upon at least one of the layers being a ferroelectric material exhibiting remnant polarization.

For at least these reasons, it is respectfully submitted that claim 1 is distinguishable over the applied art. Claims 2-10, which depend from claim 1, are likewise distinguishable over the applied art for at least the reasons discussed as well as for the additional features they recite. Thus, withdrawal of the rejection under 35 U.S.C. §103 is respectfully requested.

III. Claims 3-5 and 8-10

The Office Action asserts that claims 3-5 and 8-10 do not include any additional structural limitations. This assertion is respectfully traversed. Specifically, these claims recite an amplifier, transformer and inverter, respectively, in addition to the device of claims 1 and 2. Thus, the amplifier, transformer and inverter each constitute an additional structural feature.

IV. Conclusion

For at least these reasons, it is respectfully submitted that this application is in condition for allowance.

Should the Examiner believe that anything further is desirable in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned representative at the telephone number listed below.

Respectfully submitted,



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Date: November 1, 2002

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